

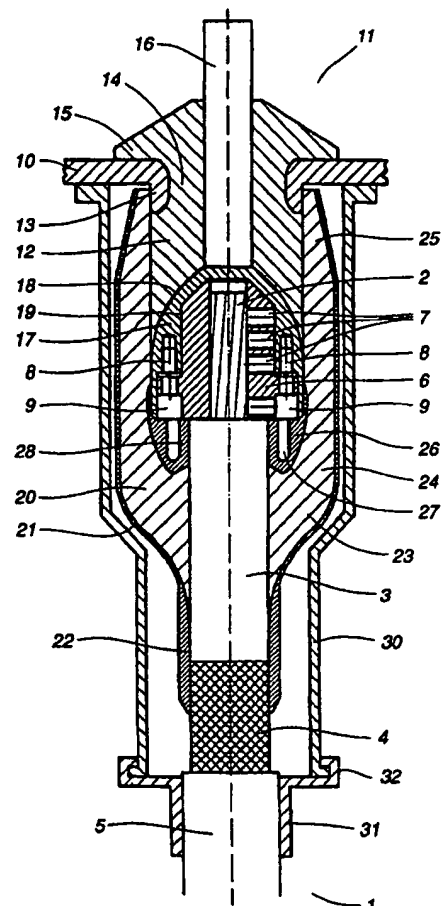
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/SE96/01087 (22) International Filing Date: 3 September 1996 (03.09.96) (30) Priority Data: 9503048-2 5 September 1995 (05.09.95) SE (71) Applicant (for all designated States except US): ASEA BROWN BOVERI AB [SE/SE]; S-721 83 Västerås (SE). (72) Inventor; and (75) Inventor/Applicant (for US only): JOHANSSON, Leif [SE/SE]; Alströmersgatan 4 A, S-441 31 Alingsås (SE). (74) Agent: LUNDBLAD VANNESJÖ, Katarina; Asea Brown Boveri AB, Patent, S-721 78 Västerås (SE).		(81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report. In English translation (filed in Swedish).

(54) Title: CABLE TERMINATION

(57) Abstract

A cable termination for connection of a high-voltage cable (1) with a solid insulating material to an insulated conductor (16). To create a favourable potential distribution of the electric field strength, a field-controlling member (20), a so-called stress cone, is arranged surrounding the cable (1). The surrounding stress cone is made of insulating elastic material with an outer conducting coating (21) which is electrically connected to an exposed outer conducting layer (4) of the cable. The conductor (2) of the cable is electrically connected to a plug-shaped contact (6). The connected conductor (16) is axially fixed to an insulating body (12) and is electrically connected to a sleeve-shaped contact (17). The two contacts are brought together into one coupling (6, 17) with good electrical contact and mechanical resistance. The coupling is surrounded by the stress cone (20) so as to obtain sufficient insulation between the coupling and the outer coating of the stress cone.



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Cable termination

TECHNICAL FIELD

5 The present invention relates to a cable termination of the kind referred to in the preamble to claim 1. The cable termination is designed for high- and medium-voltage cables (power cables) in the voltage range of up to 450 kV which are insulated with a solid insulating material, preferably
10 crosslinked polyethylene (PEX). The cable termination is adapted to be used for connection to electric switching devices and other connection objects with insulation of solid insulating material, liquid or pressure gas, such as, for example, insulators and metal-enclosed switchgear. Other
15 fields of use are jointing into a corresponding power cable or to other cables, for example paper-insulated power cables.

BACKGROUND ART

20 To obtain a voltage-grading termination on a high-voltage cable with insulation of crosslinked polyethylene (PEX), there is often used some form of a field-controlling component, a so-called stress cone, of insulating elastic material partially surrounded by a conducting external
25 coating. The stress cone is intended to control the electric field strength around the cable end such that the field-strength gradient along the cable insulation is maintained sufficiently low to avoid partial discharges and hence the risk of breakdown of the insulating medium surrounding the
30 cable termination. Normally, at low voltages, the insulating medium consists of air, which provides simple and inexpensive terminations which are easy to handle. At high voltage, however, such devices become bulky. These types of cable terminations are often complicated and time-consuming to
35 install and do not allow the component to be tested prior to energizing.

In order to obtain reasonable dimensions of a cable termination at high or medium voltage, a PEX cable is often provided with a liquid-insulated termination in an electrically insulating enclosure of plastic or a ceramic material. Such a design, however, entails increased costs of the insulating fluid and its insulating enclosure, as well as costs for expansion volume for the thermal expansion of the insulating fluid. A problem with the terminations filled with insulating fluid is also the risk of leakage.

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From the patent document SE 417 658, a cable termination is previously known, with the aid of which the need of insulating fluid has been eliminated. This cable termination is intended to be connected to a metal-enclosed switchgear unit insulated with an insulating gas, for example SF₆, the insulating gas being utilized for insulating also the cable termination. In this case, the field-controlling stress cone is applied directly to the pressurized insulating gas, thus obtaining a compact design with the possibility of saving costs.

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A problem with the cable termination described above is the sealing. Because of its elasticity, the stress cone has limited possibilities of resisting the stresses exerted by the gas pressure. This has necessitated the introduction of special support members to prevent the stress cone from being deformed or pushed out of the enclosure. An additional problem with the known termination is that the introduced support members, which in principle form a stiff tube, may contribute to deformation of the insulation of the cable and of the stress cone when being loaded. This may result in spark discharge, which successively destroys the insulation.

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From the patent document SE 501 342, a cable termination of the above-mentioned kind is previously known, which to a certain extent solves the above-mentioned problems. A number

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of stiff ring segments are inserted in the transition between the stress cone and the enclosure, in which case the force exerted by the gas pressure against the stress cone is transferred to a mounting flange provided at the enclosure.

5 However, the known cable terminations do not constitute any solution to the first-mentioned problems, namely, complicated installation and small possibilities of inspecting, for example, the tightness of a gas-filled enclosure in advance. However, the possibility of rational installation with

10 products tested in advance is of great importance in industry of today.

SUMMARY OF THE INVENTION

15 The object of the present invention is to achieve, in a power cable with solid insulation, a cable termination with small dimensions and which with rational methods can be connected to an electric circuit so as to form a closed current path without the risk of flashover. The termination is intended to

20 eliminate the disadvantages mentioned above and permit a rapid and leakage-free installation without handling oils at the site of the installation. The cable termination is to be able to withstand mechanical load and also permit functions, such as tightness and flashover, to be tested in advance.

25 Primarily, the cable termination is intended for direct connection to metal-enclosed switchgear insulated with SF₆ gas but may also be advantageously used, for example, for jointing cables, connection to an electric switching device, or to other electric outdoor components etc. The meritorious

30 properties stated above are achieved according to the invention by a cable termination with the features described in the characterizing part of claim 1. Advantageous embodiments are described in the characterizing parts of the subsequent dependent claims.

According to the invention, the cable termination is designed as a so-called dry cable termination, thus eliminating the handling of oil at the site of the installation as well as excluding the risk of leakage. The cable termination comprises one female part and one male part which are assembled into an electrically conducting mechanical joint surrounded by a stress cone, formed from insulating rubber, with an externally conducting coating. The male part is composed of the cable with a contact member attached to the stripped conductor thereof. The female part is composed of an insulating body with a contact sleeve which is cast into one end thereof and which is connected to a conductor running coaxially through the insulating body. This conductor is electrically connected to the circuit which is to be connected. The insulating body is adapted to be rigidly attached to the circuit, such that the attachment becomes gas-tight and can withstand mechanical forces.

The contact member fixed to the cable conductor is adapted to be pushed into the sleeve body arranged at the connecting conductor. The contact member is fixed to the sleeve body by means of a mechanical joint such that a good contact is obtained and such that the joint also serves as a tensile strain relieving device. The stress cone, which was previously fitted onto the cable, is passed over the joint so as to surround the joint. At the same time, the externally conducting coating of the stress cone is brought into contact with the externally conducting layer of the cable, thus forming a favourable field distribution.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained in greater detail by description of an embodiment with reference to the accompanying drawings, wherein

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- Figure 1 shows a cross section of a cable termination according to the invention for connection to a gas-insulated metal-enclosed switchgear unit,
- 5 Figure 2 shows a cross section of a gas-insulated insulator for outdoor use and a cable termination according to the invention, connected thereto,
- 10 Figure 3 shows a cross section of a joint between two PEX cables, in which two oppositely located cable terminations according to the invention are used,
- 15 Figure 4 shows a cross section of a joint between a PEX cable and a power cable with paper insulation, a cable termination according to the invention being used to connect the PEX cable.

DESCRIPTION OF THE PREFERRED EMBODIMENT

- 20 A connection of a high-voltage cable 1, insulated with a solid insulating material, into a metal-enclosed switchgear unit (not shown) is shown in Figure 1. The cable 1 has an inner conductor 2, usually of copper or aluminium, surrounded by a solid insulation 3, preferably of crosslinked
- 25 polyethylene (PEX). The insulation 3 is surrounded by an outer conducting layer 4, which is extruded on the insulation. Surrounding this conducting layer 4 and in electrical contact therewith is a metallic shield (not shown), preferably of copper wires. Finally, the cable is
- 30 surrounded by a sheath 5, for example of polyethylene (PE), which is tight and has good mechanical properties. On the exposed cable conductor 2 there is arranged a circular contact plug 6, which is fixed to the conductor with a screw joint 7, the task of which is to ensure good electrical and
- 35 mechanical connection between the contact plug 6 and the cable conductor 2.

An only partially shown attachment flange 10 comprising a hole 11, limited by a circular collar 13 of the attachment flange folded out towards the cable, is gas-tightly attached to a switchgear unit (not shown). Through the hole 11 is
5 arranged a cylindrical insulating body 12 with a slot 14 for the collar 13 and with a corbelled-out portion 15 which makes contact with the inside of the attachment flange to bring about good sealing. The insulating body 12 is homogeneous and preferably consists of epoxy, which is cast to the hole 11
10 such that no air pockets arise. Through the insulating body there extends coaxially a rod-shaped conductor 16, for example of copper, which, with good tightness, is attached to the insulating body 12. On the inside of the switchgear unit, the conductor is connected to an electric component (not
15 shown), with which the cable 1 is adapted to form a closed circuit. The end of the conductor facing the cable is connected to a contact sleeve 17, the outside 18 of which is cup-shaped with an outer diameter equal to that of the insulating body and gas-tightly cast into the insulating body
20 12.

The contact plug 6 is adapted to be inserted into the contact sleeve 17 so as to obtain a coupling with good electrical conductivity. A screw joint 8 fixes the contact plug to the
25 contact sleeve, whereby the screw joint is adapted such that the screws 9 are oriented in an axial direction and are accessible for tightening outside the cable insulation 3.

In order to control the electric field such that a suitable
30 level of the field strength in air is attained, a stress cone 20 of an elastically insulating material with an outer conducting coating 21 is adapted to surround the joint. The stress cone 20 is preferably constructed from partly insulating, partly conducting EPDM rubber. To achieve a suitable
35 distribution of the electric field strength, that part of the stress cone facing the cable is formed with a cylindrical

neck 22, of a conducting material, which surrounds the cable insulation and is electrically connected to the outer conducting layer 4 of the cable. In a direction towards the cable end, the neck changes into a cone-shaped part 23 of insulating rubber, where the conducting coating follows the outer contour. The stress cone then changes smoothly into a cylindrical portion 24 which surrounds the joint and part of the insulating body 12. The cylindrical part has a thickness which is sufficiently large to bring about a satisfactory insulation around the joint. In a direction towards the attachment flange 10, the stress cone then changes into a slightly cone-shaped part 25, converging towards the attachment flange, which surrounds the insulating body 12 and extends so far towards the attachment flange as to overlap the collar 13.

The stress cone has a coaxial through-hole in two sections with different inner diameters. The narrower hole section is intended to tightly surround the cable insulation and has, in non-extended state, an inner diameter smaller than the diameter of the cable insulation. In the same way, the wider hole section is intended to tightly surround the insulating body 12 and has, in a non-expanded state, an inner diameter smaller than the outer diameter of the insulating body. In the area around the transition from the narrower to the wider section, a ring 26 of electrically conducting rubber is arranged. The ring 26 is in electrical connection with the contact sleeve 17 and the contact plug 6 and adapted to smoothly control the electric field so as to avoid field concentrations. In a rotationally symmetrical cross section, the ring is exposed on the inside of the stress cone 20 at the transition between the two sections and a certain distance into the respective section and extends arcuately into the insulating layer of the stress cone. An annular recess 27 with an axially oriented cross section, in the form of a gorge, defines a collar 28 which is adapted, with a dimen-

sional contact pressure, to ensure good sealing between the cable insulation and the stress cone. The recess also allows the edge of the wider hole section to make contact, with a dimensionable pressure, with the contact sleeve 17 so as to
5 prevent the occurrence of field-disturbing air pockets.

For mechanical protection, the entire cable termination is enclosed by a protective sleeve 30 of metal, which is connected to a ring 31 arranged around the cable and composed
10 of two halves. The two halves comprise a connecting collar 32 for fixing the protective sleeve 30 and are adapted to mechanically fix the cable 1 by means of a clamping joint.

In an advantageous embodiment of the invention, the contact
15 surface 19, which is common to the contact plug 6 and the contact sleeve 17, may be arranged cylindrical or slightly conical. Axially oriented spring elements (not shown) or the like may also be introduced into the contact surface 19 to ensure good electrical contact. The insulating body is not
20 limited to being cast into an attachment flange but may also be formed in two parts, which are attached to each other from separate sides of the hole in the flange. The insulating body may also be cast or flanged directly to the casing of the switchgear unit.

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Figure 2 shows a cable termination connected to a gas-insulated insulator 40. The insulator comprises an insulator
41 of porcelain or polymeric material and a socket in the form of a mounting flange 42. The insulating body 12 described above is here extended into the insulator where it is
30 shaped as a field-controlling component 45 of a previously known appearance. A layer of a conducting coating 46 surrounds that part of the field-controlling component 45 facing the cable and is electrically connected to an attachment
35 flange 43, into which the extended insulating body is attached. In an advantageous embodiment, the conducting

coating consists of a collar pressed from the attachment flange. The attachment flange 43 is adapted to be gas-tightly fixed to the insulator 40 by means of a joint, in which case a seal, preferably an O-ring 44, makes contact with the mounting flange 42 or the end surface of the insulator 41. Coaxially through the extended insulating body runs a rod-shaped conductor 47, which, in its end facing the cable, is connected to a contact sleeve 17 of the above-mentioned kind. The other end of the conductor is formed with a jointing device 48 to create a closed current path with the circuit to be closed. In a manner described above, a contact plug 6, attached to the cable conductor, is inserted into the contact sleeve 17, and the insulating body 12 is surrounded by a stress cone 20 of the kind described above.

Figure 3 shows a joint between two PEX cables arranged with the aid of two cable terminations according to the above, turned towards each other. A mirror-symmetrical insulating body 50 common to both cable terminations surrounds a conducting jointing member 51, a contact sleeve 17 being connected to each end thereof. In the manner described above, a contact plug 6 is inserted into each contact sleeve, which contact plug 6 is fixed to the respective cable conductor by means of a joint. A stress cone 20 of the type described above, with a inner conducting ring 26 and an outer conducting coating 21, surrounds the respective joint such that the outer conducting coating of each stress cone is electrically connected to each other. A ring 52 of conducting material is cast into the surface of the central part of the insulating body to achieve a satisfactory overlap between the stress cones so that no electric stress concentrations are obtained.

Figure 4 shows how a joint between a PEX cable and a cable 60 insulated with paper 61 may be achieved by means of the cable termination described above. The paper 61 is impregnated with an insulating fluid and wound around a conductor 62 which is

electrically connected, by means of a splice joint, to a conducting, rod-shaped connecting piece 63, which in its other end is connected to a contact sleeve 17 of the kind described above. A contact plug 6 of the kind described above is inserted into the contact sleeve, the conductor of the PEX cable 1 being electrically connected to the contact plug. The connecting piece 63 is coaxially cast into an insulating body 64, which is tightly cast to an attachment flange 10 and which is conically extended towards the paper-insulated cable. A stress cone 20 of the kind described above is arranged, surrounding the contact sleeve 17 with the inserted contact plug 6, which stress cone makes contact with the insulation of the PEX cable and with the insulating body 64. Making contact with the conical extension of the insulating body, an insulating sleeve body 65 is arranged. This sleeve body 65 is composed of paper which is impregnated with insulating fluid and wound around the joint into the desired thickness. The sleeve body thereby surrounds part of the paper insulation 61 of the cable, the conductor 62 and the jointing body 63 and is wound in such a way as to prevent air pockets. Connected to the mounting flange and surrounding the sleeve body, a container 66 filled with insulating fluid is arranged. The casing of the container is made of solid material, for example metal, and at the other end of the container a bushing 67 is arranged for fixing of and sealing against the paper-insulated cable 60.

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CLAIMS

1. A cable termination for a high-voltage cable (1) with a solid insulating material for connection to an insulated conductor (16), whereby, to create a favourable potential distribution of the electric field strength, there is arranged a field-controlling member (20), surrounding the cable (1), of insulating elastic material with an outer conducting coating (21) which is electrically connected to an exposed outer conducting layer (4) of the cable, characterized in that the conductor (2) of the cable and the connected conductor (16) are connected in an electrical coupling (6, 17), comprising a first contact (6) in electrical connection with the cable conductor (2) and a second contact (17) in electrical connection with the connected conductor (16), that the connected conductor (16) is coaxially fixed to an insulating body (12), to which the second contact (17) is attached, and that the field-controlling member (20) surrounds the coupling (6, 17).
2. A cable termination according to claim 1, characterized in that the second contact (17) is sleeve-shaped and that the first contact (6) is plug-shaped and adapted to be inserted into the sleeve-shaped contact (17).
3. A cable termination according to claim 1 or 2, characterized in that the field-controlling member (20) comprises an axial through-hole in two sections, whereby the narrower hole section in non-expanded state has a diameter smaller than that of the cable insulation (3) and the wider hole section in non-expanded state has a diameter smaller than that of the insulating body (12), such that the field-controlling member in inserted position is expanded and makes contact with the cable insulation and the insulating body, respectively, with a sufficient contact pressure to avoid field-disturbing air pockets.

4. A cable termination according to any of the preceding claims, characterized in that field-controlling member (20) comprises an elastic ring (26) of electrically conducting material, which is exposed on the inside and which is
- 5 electrically connected to the coupling (6, 17) and adapted to create a favourable electric field distribution between the coupling (6, 17) and the outer conducting coating (21) of the field-controlling member (20).
- 10 5. A cable termination according to any of the preceding claims, characterized in that the insulating body (12) is attached to an attachment device (10) arranged at the connecting conductor (16) such that the body withstands mechanical forces exerted by the cable conductor (2) or the
- 15 connected conductor (16).
6. A cable termination according to any of the preceding claims, characterized in that the insulation of the connecting conductor (16) comprises an insulating medium of a
- 20 solid material.
7. A cable termination according to any of the preceding claims, characterized in that the insulation of the connecting conductor (16) comprises an insulating medium of a
- 25 gas.
8. A cable termination according to any of the preceding claims, characterized in that the insulation of the connecting conductor (16) comprises an insulating medium of a
- 30 fluid.
9. A cable termination according to any of the preceding claims, characterized in that the coupling (6, 17) exhibits a smooth limiting surface (18) with no projecting edges, thus
- 35 limiting the electrical stress.

10. A method for connection of a high-voltage cable (1) with a solid insulating material to an insulated conductor (16), whereby, to create a favourable potential distribution of the electric field strength, there is arranged a field-
- 5 controlling member (20), surrounding the cable (1), of insulating elastic material with an outer conducting coating (21) which is electrically connected to an exposed outer conducting layer (4) of the cable, characterized in that the conductor (2) of the cable is brought into electrical
- 10 connection with a first contact (6) and that the connected conductor (16) is coaxially fixed to an insulating body (12) and is brought into electrical connection with a second contact (17) attached to the insulating body, whereupon the contacts are connected to each other in a coupling (6, 17),
- 15 whereupon the field-controlling member (20) previously fitted onto the cable is brought to surround the coupling (6, 17), making good contact therewith.

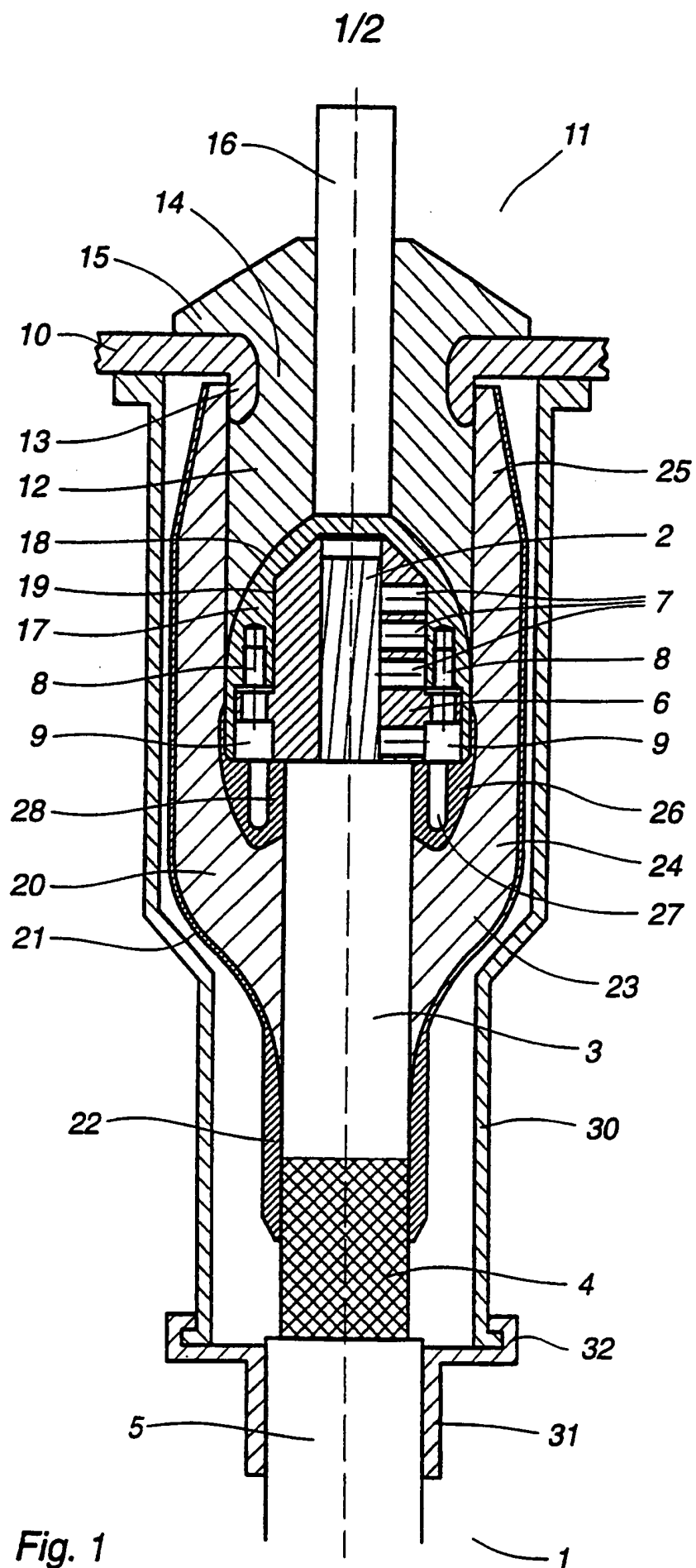
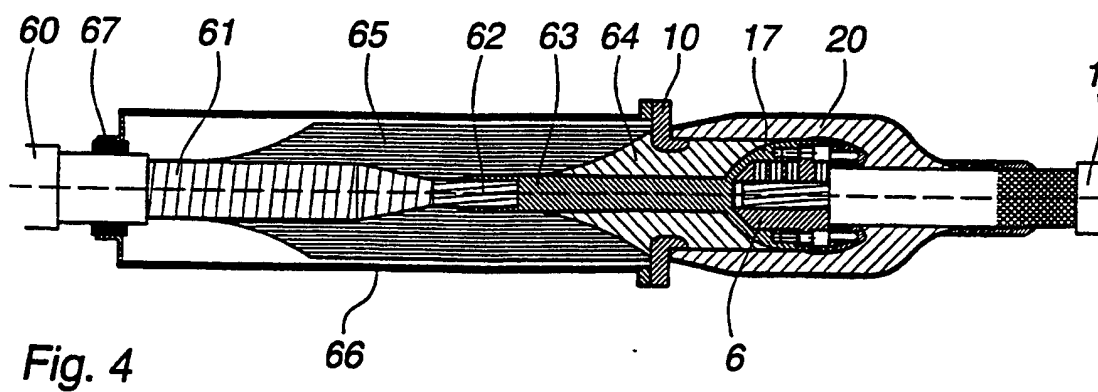
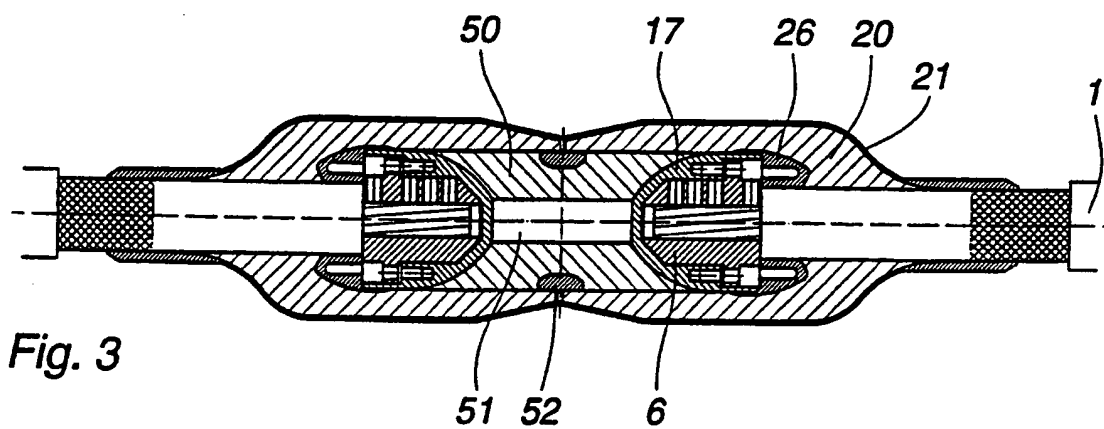
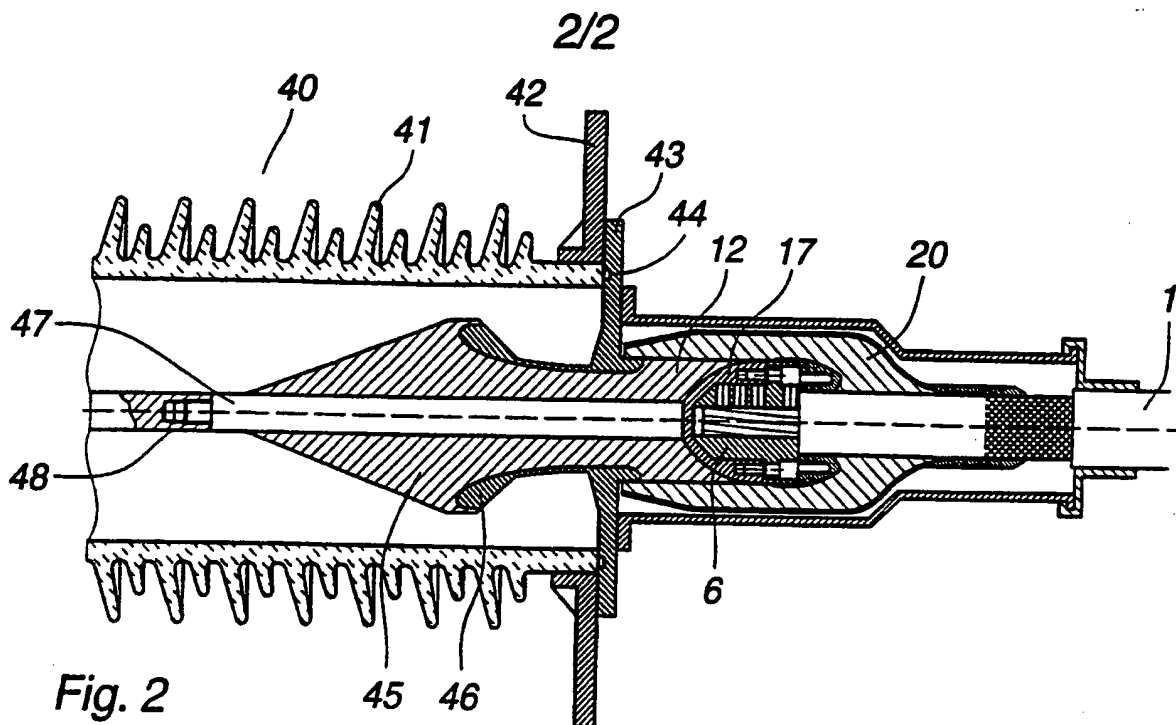


Fig. 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 96/01087

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02G 15/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4237333 A (A. CLASSON), 2 December 1980 (02.12.80)	1-10
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A	SE 501342 C2 (KABELDON AB), 23 January 1995 (23.01.95)	1-10
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INTERNATIONAL SEARCH REPORT

Information on patent family members

28/10/96

International application No.

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Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US-A- 4237333	02/12/80	CH-A-	635708	15/04/83	
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